Introduction to semiconductor for High Energy Physic using

EASY: Educational Alibava System

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Alibava systems

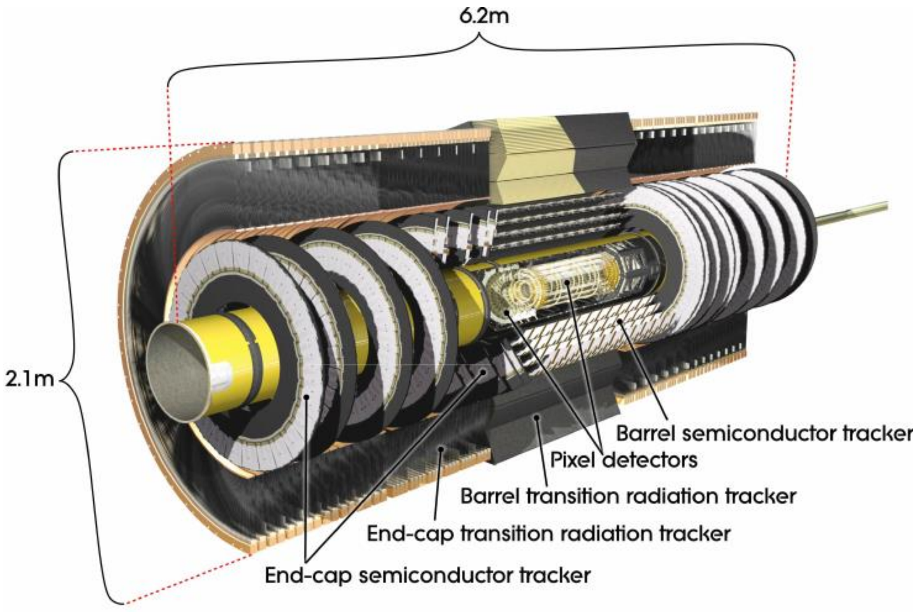
EASY

- Basic principles of silicon strips sensors
- The experimental setup (EASY system)
- Data acquisition and monitoring
- Data analysis:
  - Exercise 1: Charge collection and depletion voltage
  - Exercise 2: Strip structure and charge sharing
- For the exercises you need your google drive account
- Two windows: one for zoom and other for your google account

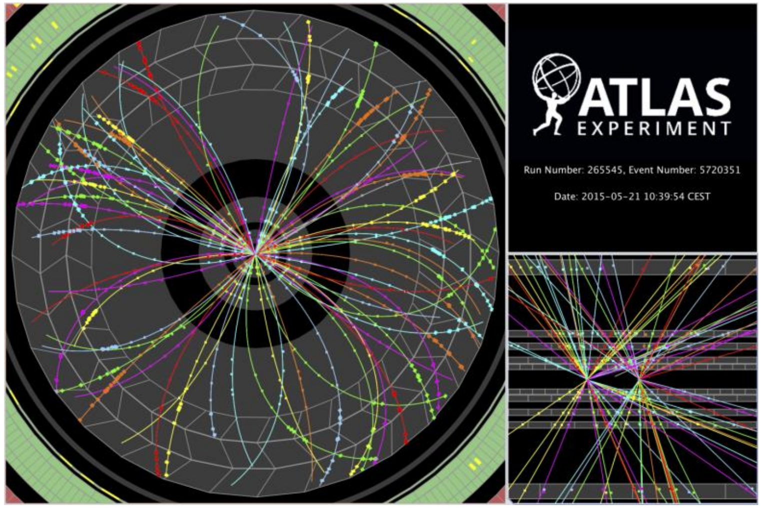
Basic principle

Silicon strip sensors are used to track the pass of charge particles in high energy physics detectors.

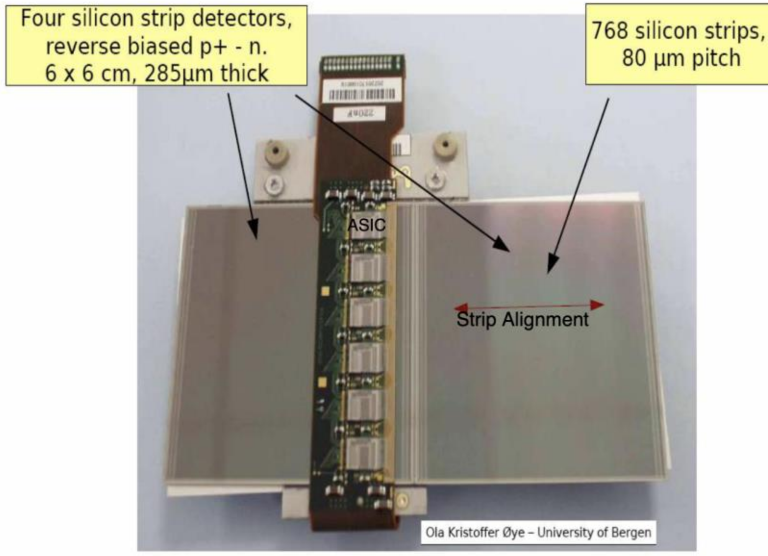
The ATLAS example



Inner Tracker ATLAS

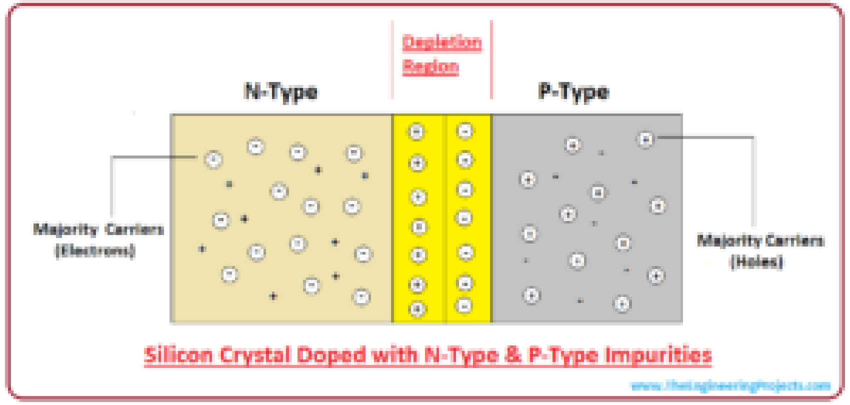


Inner Tracker ATLAS event

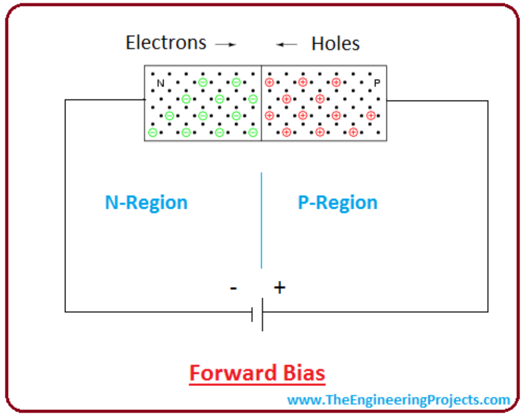


ATLAS SCT module

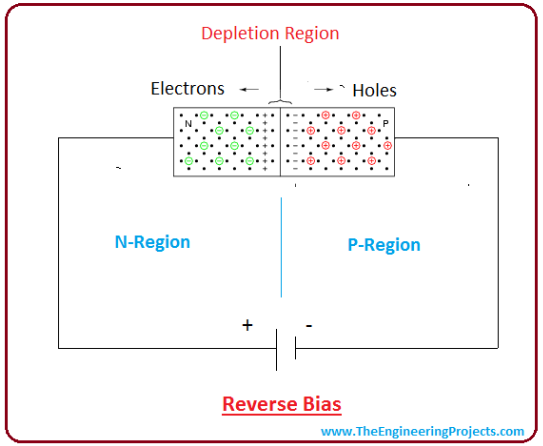
Basic principle: p-n junction



The holes present in the P region are diffuse into the N-region, leaving behind the negative charge in the P region . Electrons present at the N-region diffuse into the P-region leaving behind the positive.
As the junction is formed, each region of silicon crystal becomes depleted from major charge carriers around the junction.



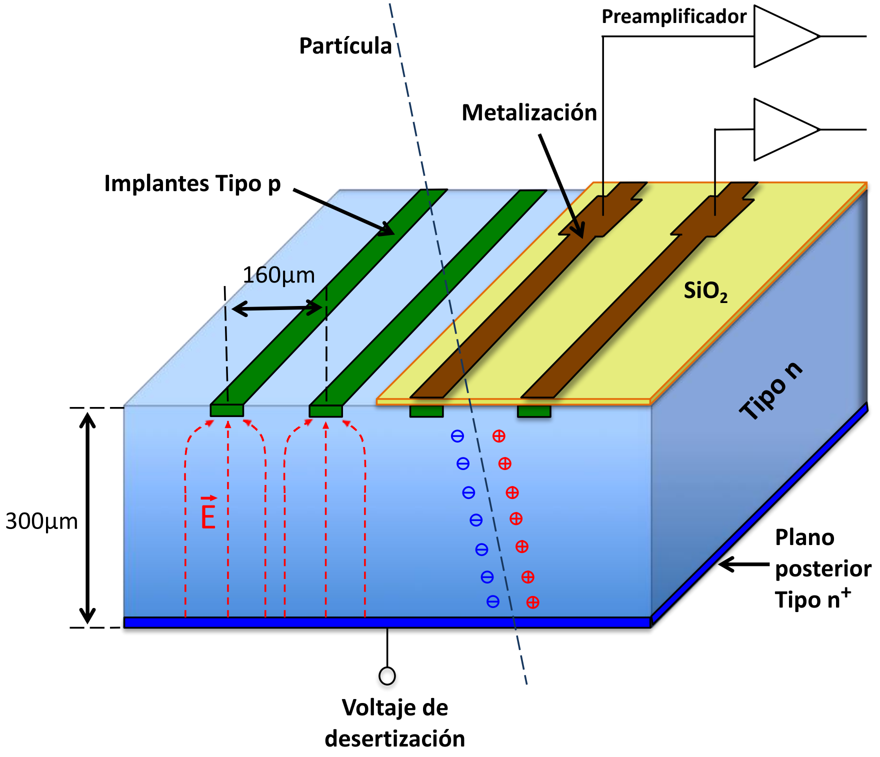
The electrons present in the N-region will push toward the P-region. Holes in the P-region will continue to diffuse into the N-region as long as the forward bias voltage is applied across the junction.

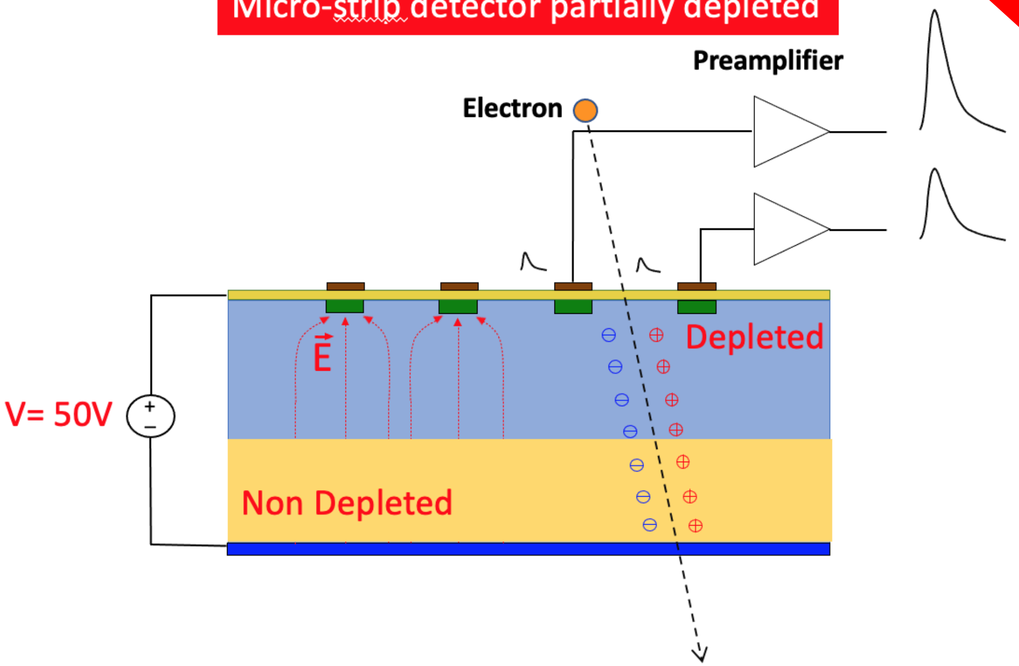


The width of depletion region behaves in proportion with the reverse bias voltage applied across the junction.
Stops the current flow between the junction.
In this condition, PN junction behaves as an insulator.

Basic principle

Exercise 1

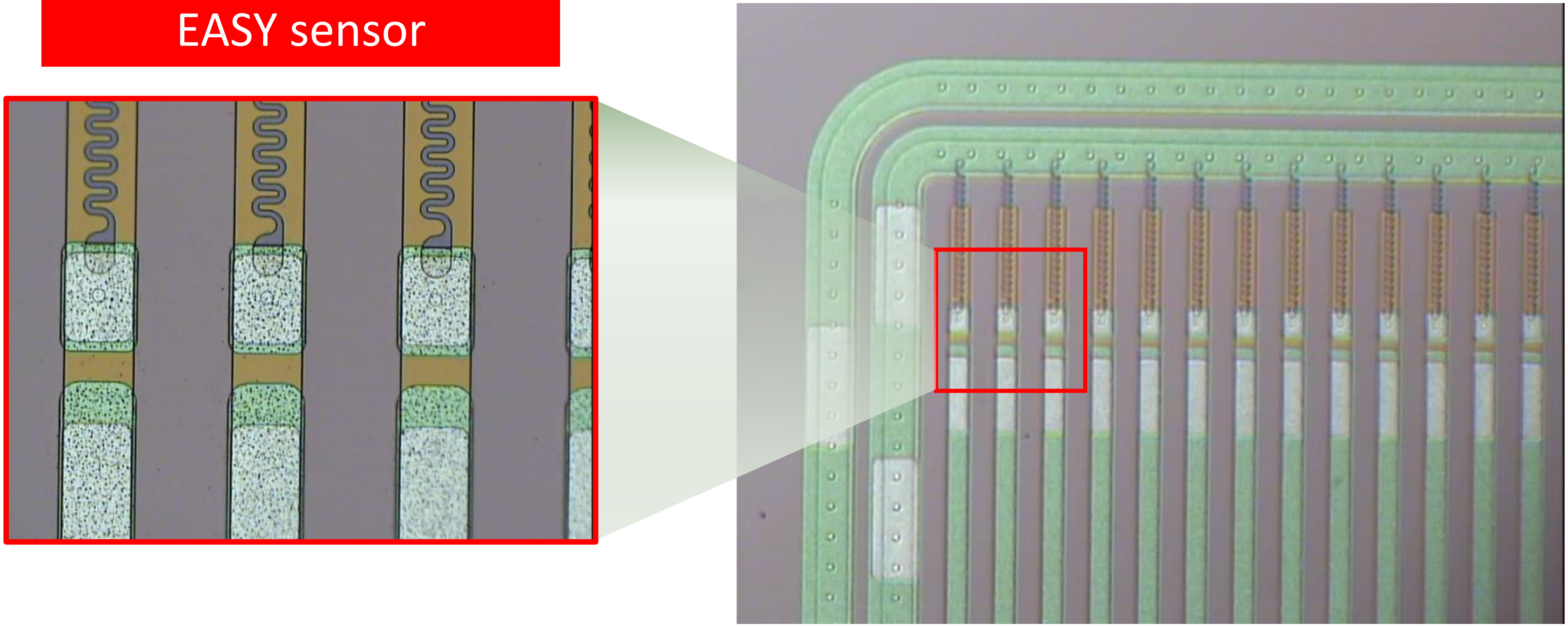




Charge collected is proportional to the depletion area

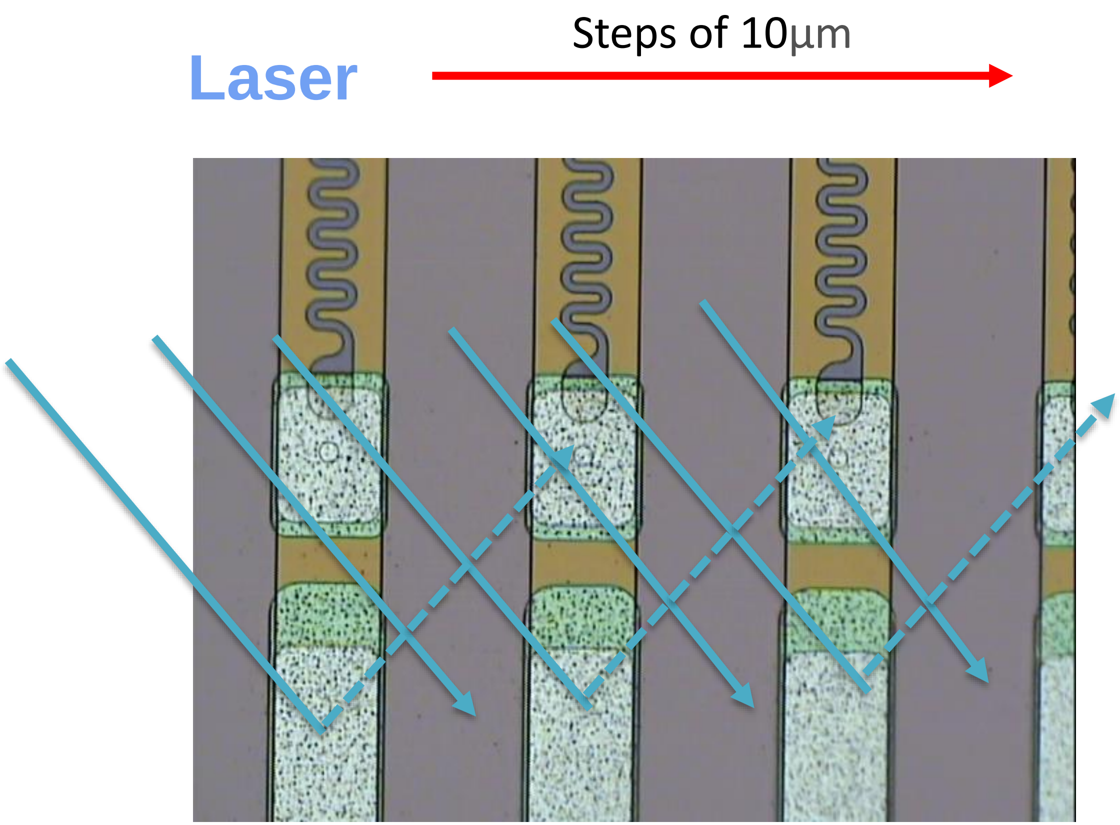
Basic principle

EASY sensor



Basic principle

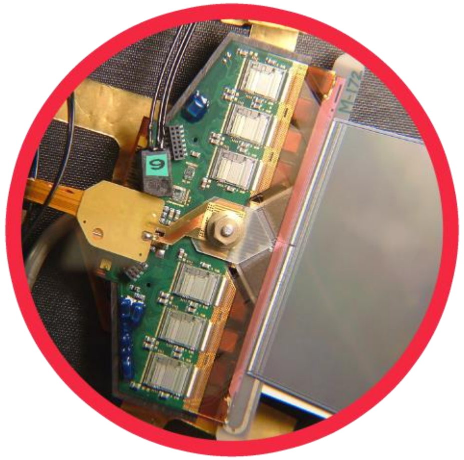
Exercise 2



EASY

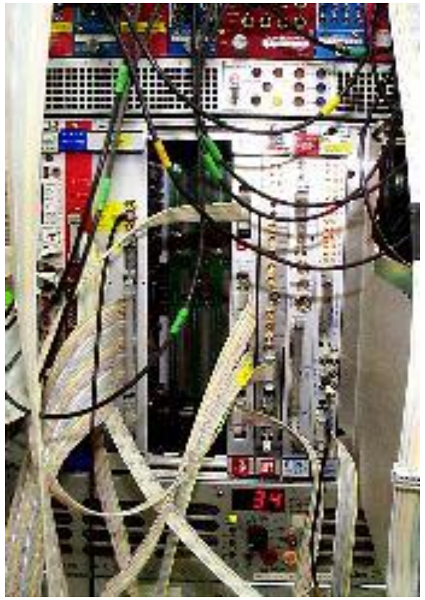
Setup components @ Lab.

Components of a silicon microstrip detectors



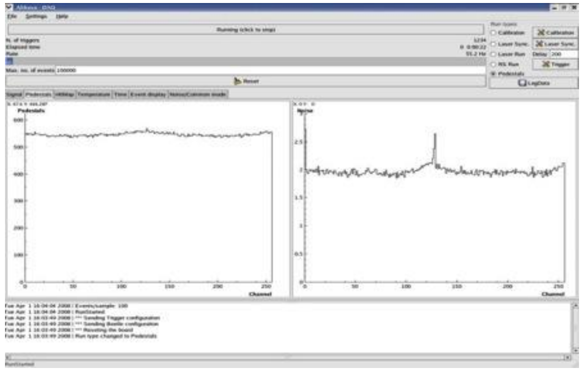
Sensor + ASIC

HV power supply



Control unit

Trigger



Data acquisition and monitoring

Source of particle

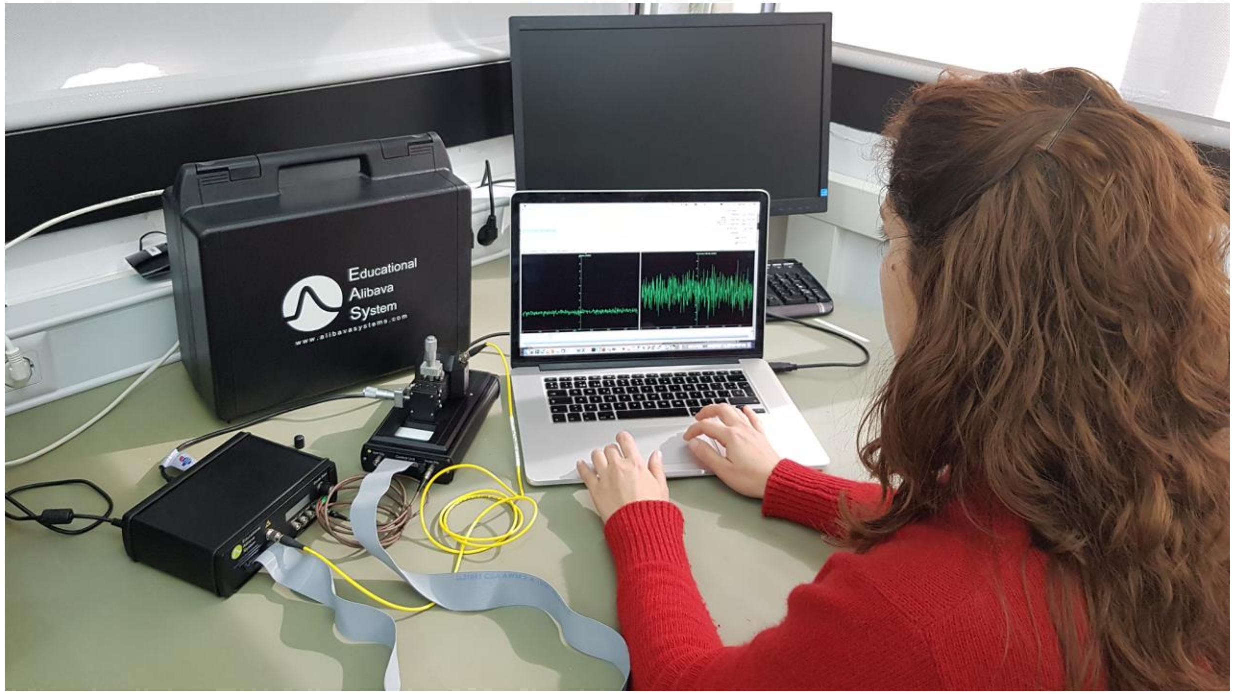
Laser

Radioactive source

EASY system

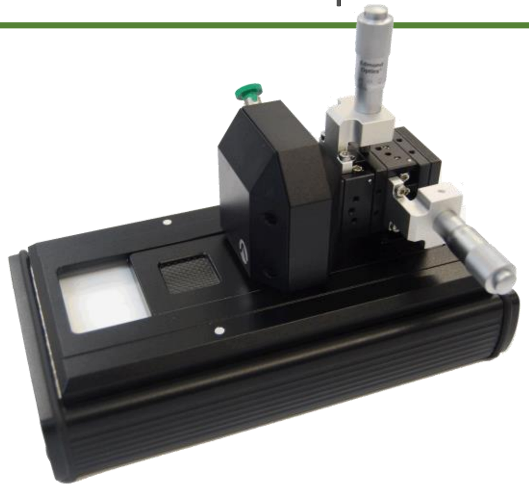
EASY is a portable, compact and complete system for microstrip ideal complex experiments with silicon microstrip detectors.

EASY SYSTEM



EASY system

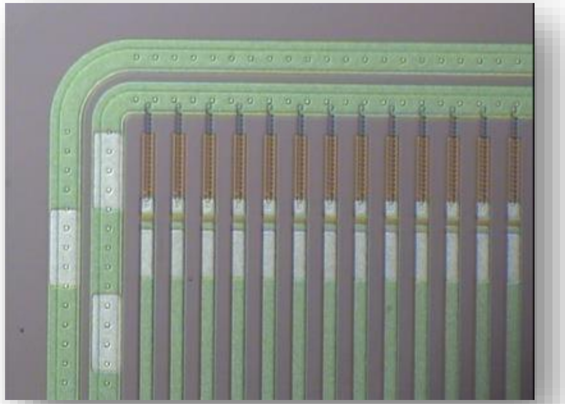
Control unit
- Data Acquisition Control.
- Processing of the sensor and trigger data
- Adjustable HV unit for microstrip sensor bias, with voltage and current display.
- Include the laser source
- Communication with computer software via USB



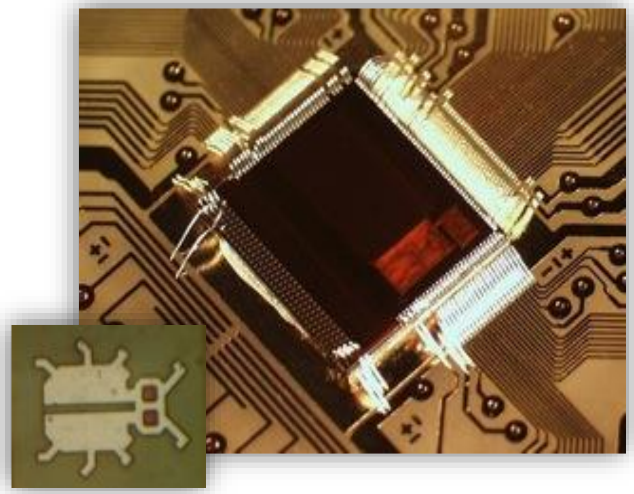
Sensor unit
- Silicon microstrip sensor and the Beetle chip.
- Opaque carbon fibre window to place radioactive source.
- Laser micropositioner and focus system.
- A diode placed under the detector provides a trigger signal.

EASY system

Silicon microstrip
- P-on-N Detector
- Size: 20x20 mm2
- Thickness: 300 µm
- Channels: 128
- Interstrip pitch: 160 µm



Beetle Characteristics
- Low noise ASIC developed for CERN/LHC experiments
- 128 channels

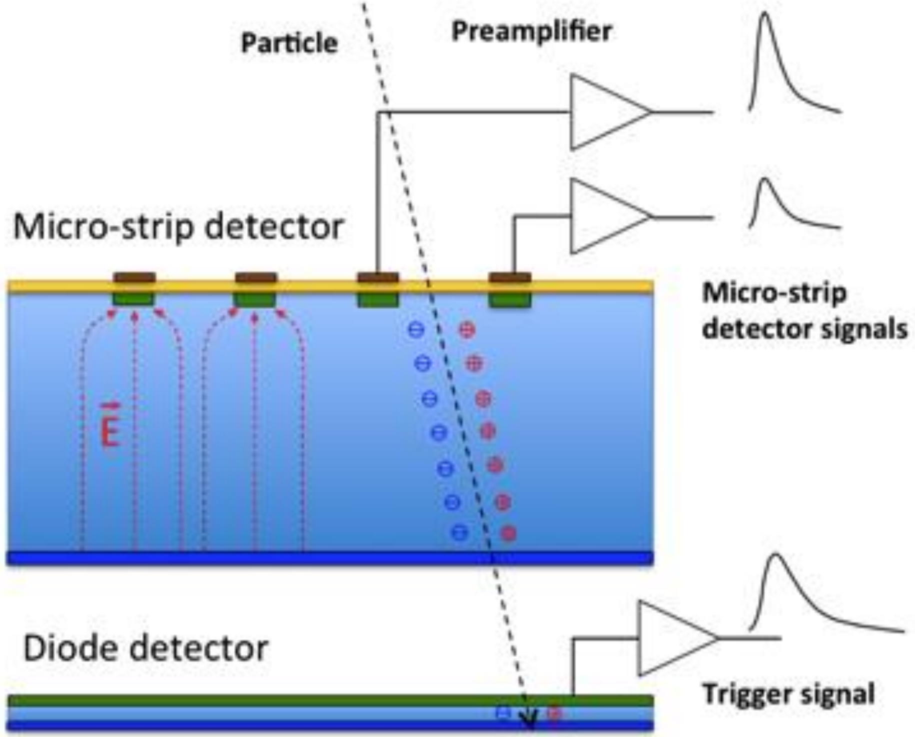


Laser source
- Wavelength: 980nm
- Pulse width: 5 ns
- Laser Spot: 20 µm
- Micropositioner resolution: 10 µm

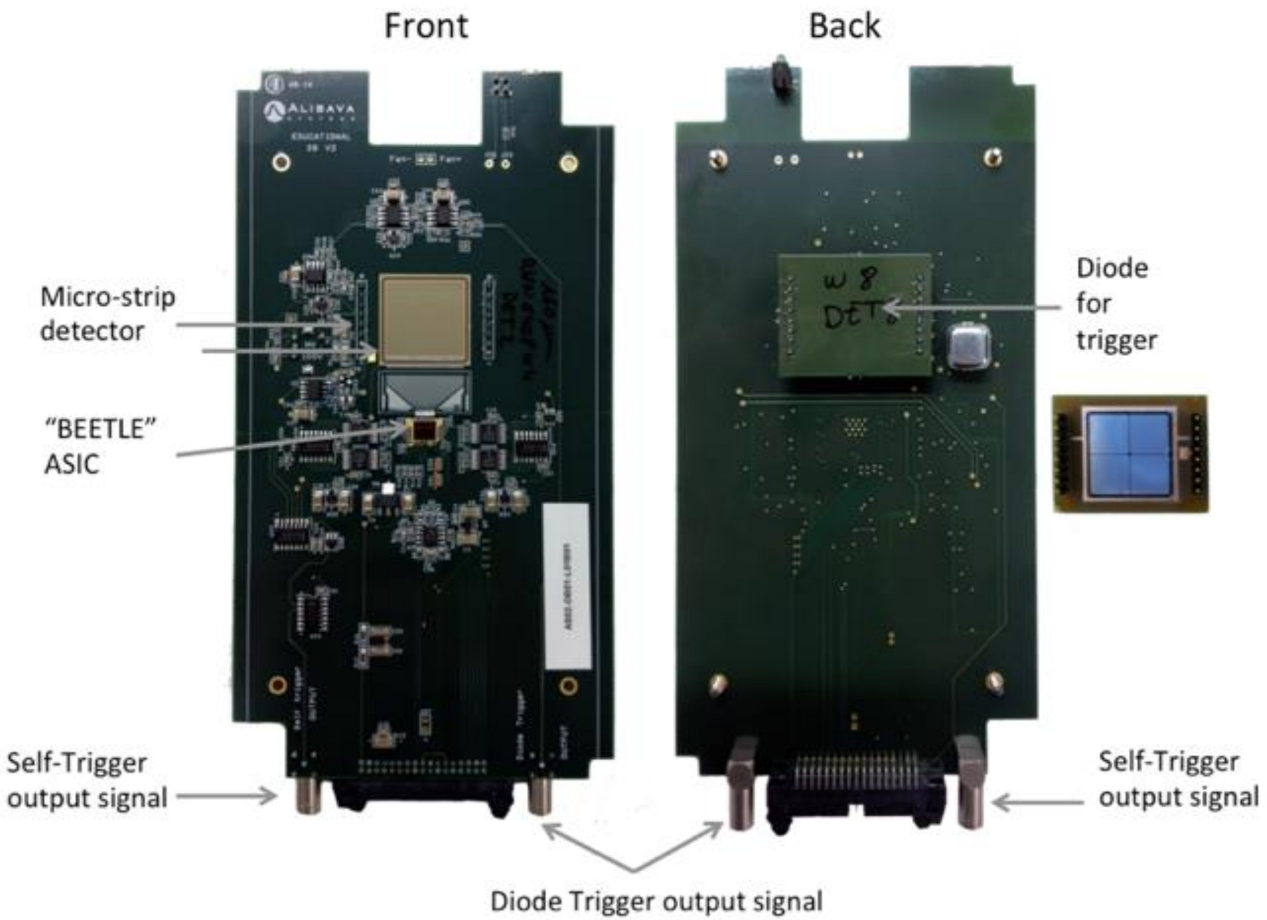
Trigger

Tigger modes:

- **External**: provided by the diode, for particles crossing the sensor.
- **Synchronised trigger**: to trigger the laser source.



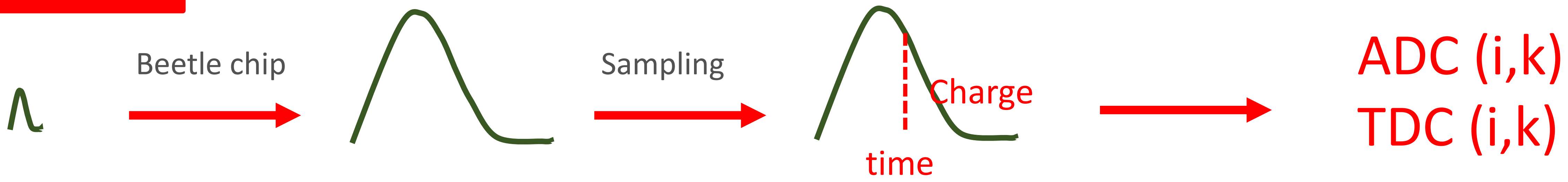
Trigger

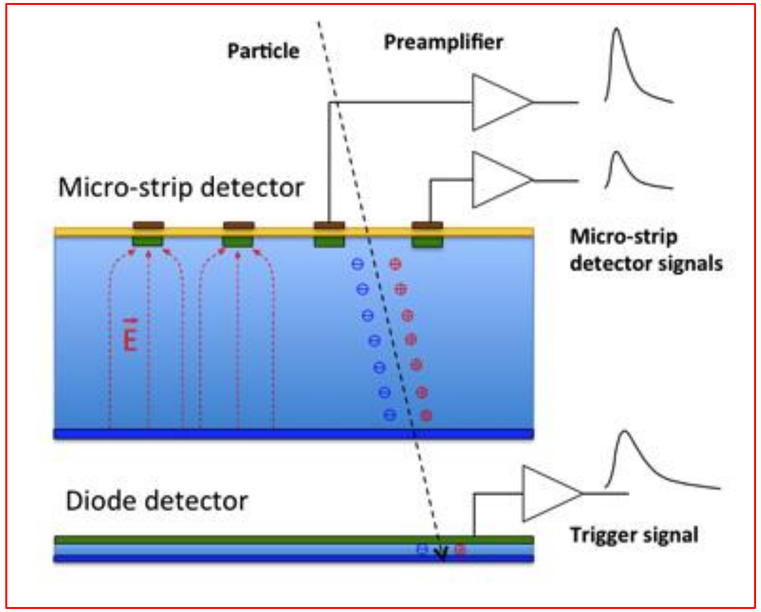


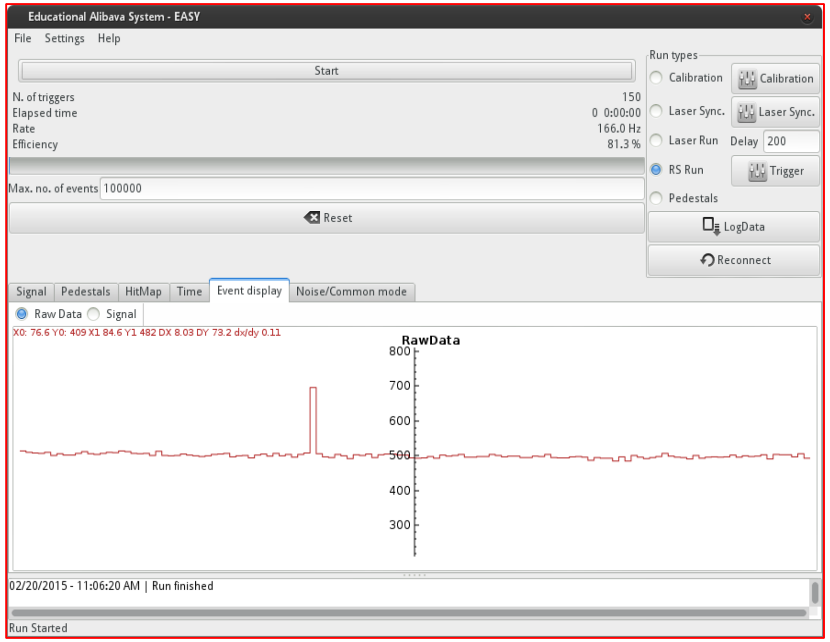
Front
Back
Micro-strip detector
"BEETLE" ASIC
Self-Trigger output signal
Diode for trigger
Self-Trigger output signal
Diode Trigger output signal

Charge collection

Strip *i* , Event *k*







Charge collection

Strip *i* , Event *k*

ADC(*i*,*k*)= Offset (*i*)+ Common Noise (*k*)+ Electronic Noise (*i*) + Charge (*i*,*k*)

$$P(i) = \frac{1}{N}\sum_{k=1}^{N} ADC(i,k)$$

$$D(k) = \frac{1}{128}\sum_{i=1}^{128}(ADC(i,k) - P(i))$$

$$Noise(i) = \sqrt{\frac{1}{N-1}\sum_{k=1}^{N}(P_c(i) - \overline{P_c}(i))^2}$$

N events
128 channels

More information

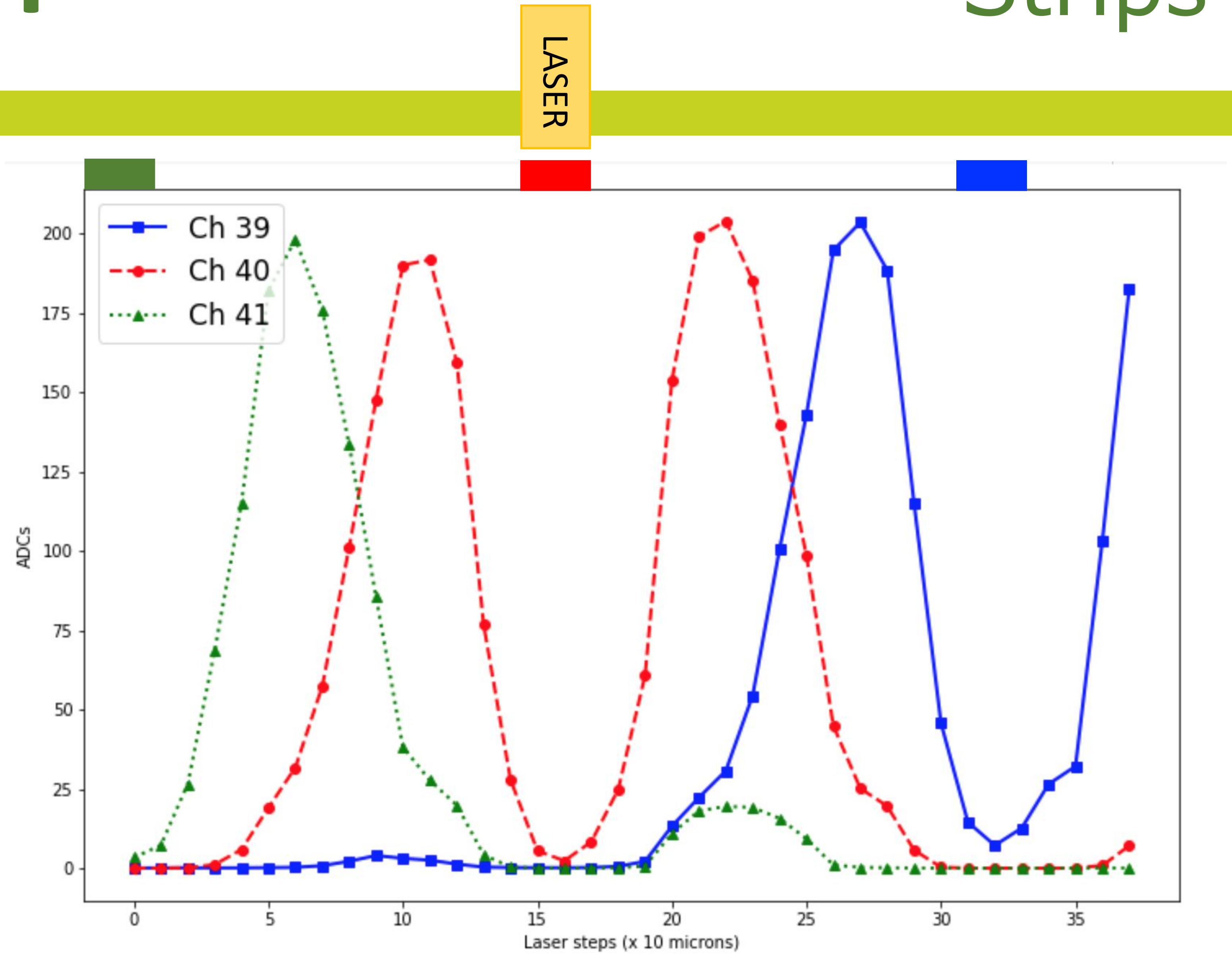
https://www.alibavasystems.com/

Alibava System youtube

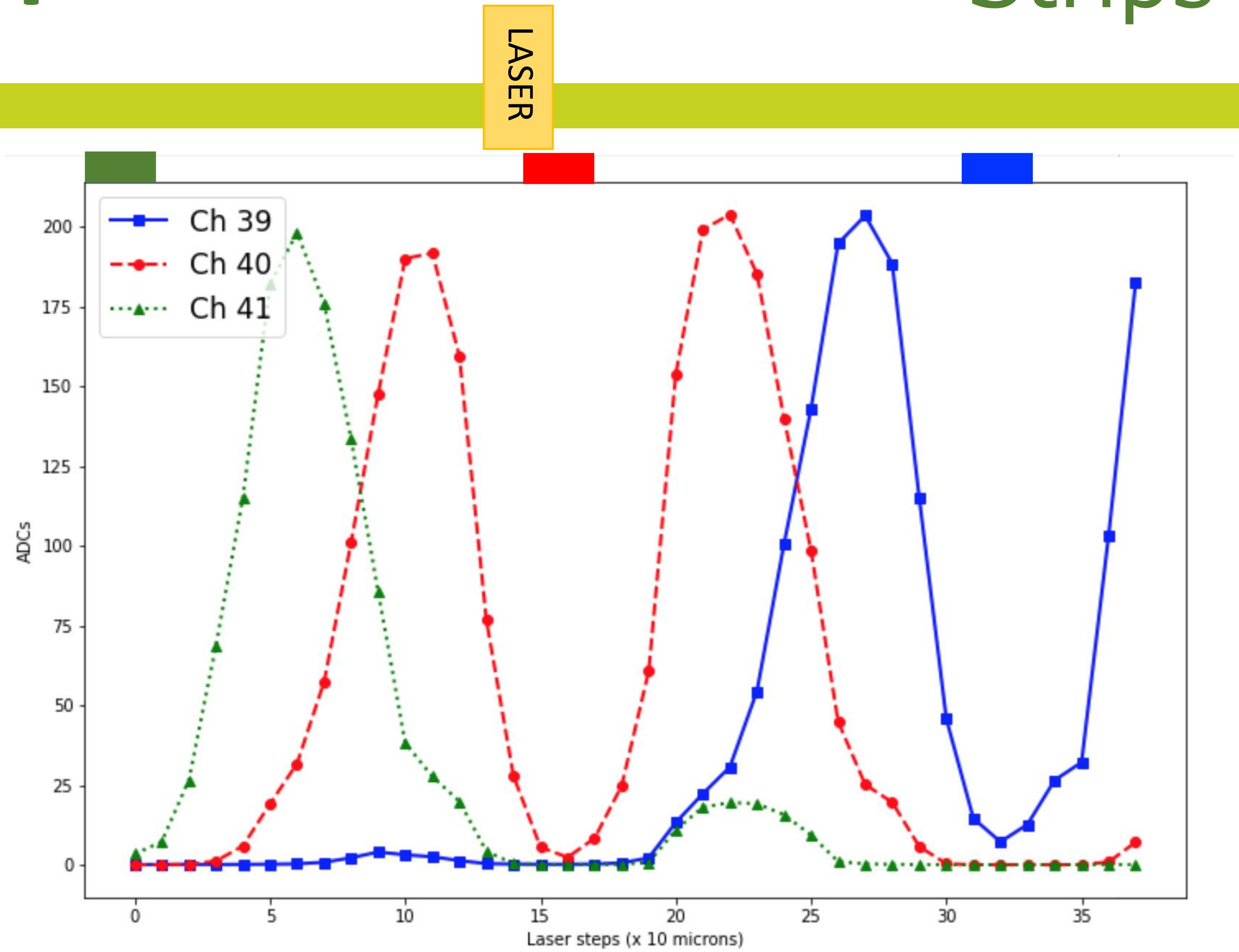
Exercise 1

Exercise 2

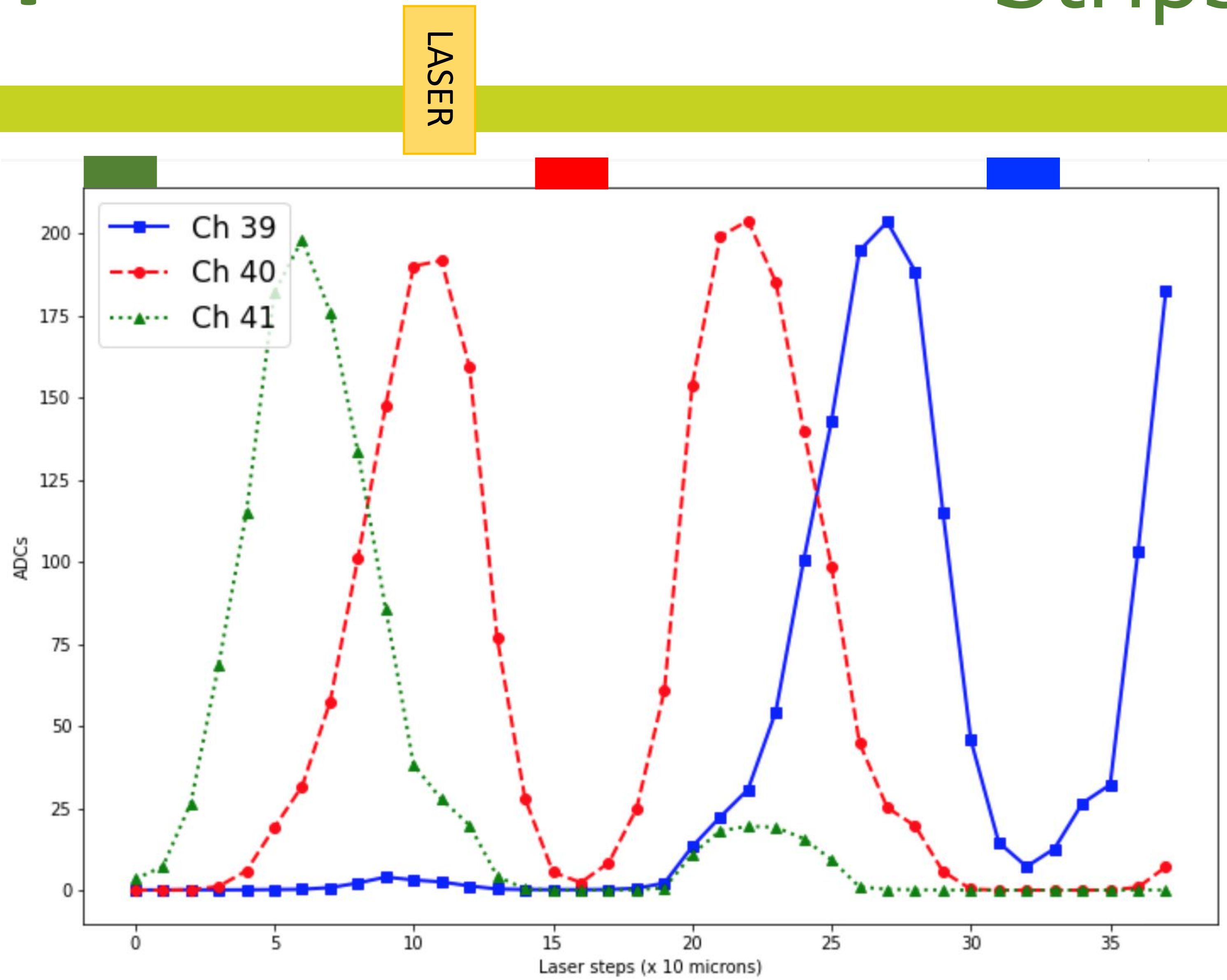
Strips exercise



Strips exercise

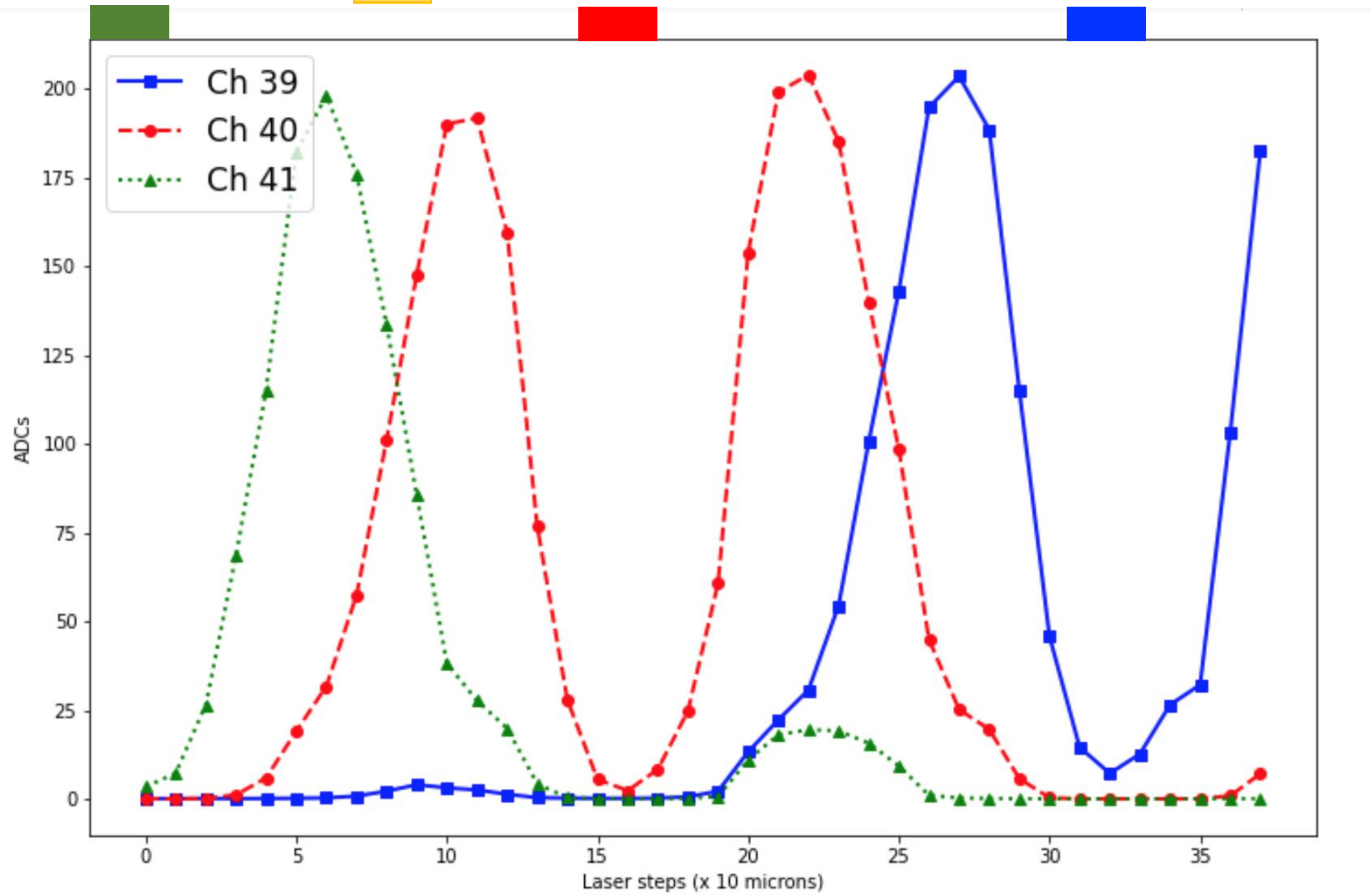


Strips exercise

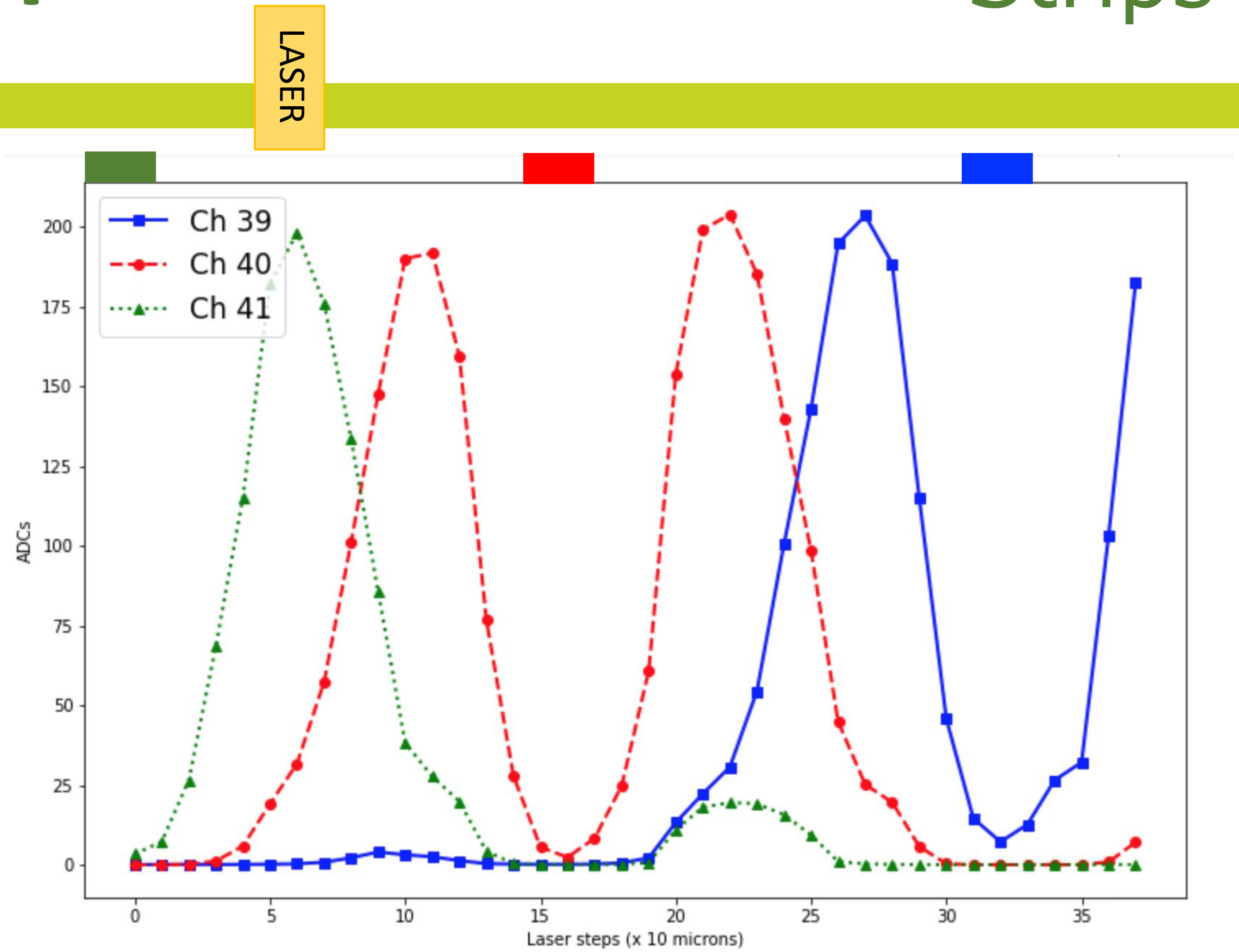


Strips exercise

LASER



Strips exercise



Strips exercise